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FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGÜEZ, PUERTO RICO

REPORT OF THE
FEDERAL EXPERIMENT STATION
IN PUERTO RICO

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The Research and Marketing Act project initiated last year, on Soil Erosion Control and Stable Crop Production, was strengthened by increased financial support and another RMA project, Establishing a Cooperative National Research Program to Develop Practical Methods and Equipment for Weed Control, was started during the year. The investigations undertaken under the latter funds were directed primarily at solving problems of fundamental importance in the field of weed control. These included studies of environmental factors affecting the persistence of herbicides in the soil and studies to determine the biochemical basis for the action 2,4-D in plants.

Important contributions have been made during the year by the insecticidal-plant section, in establishing a close correlation between total chloroform extractives and rotenone and toxicity assays of *Derris* roots. This correlation has been shown to hold not only for clones grown in Puerto Rico, but also for those grown in Nicaragua. Since evaluations for rotenone and total toxicity are tedious and expensive, the establishment of the correlations is important for evaluation studies.

The plant-breeding section achieved significant progress in making a large number of crosses between Jersey and moist-flesh varieties of sweetpotatoes. The Jersey varieties, though grown widely in the Middle-Atlantic States and in the Midwest, flower rarely or not at all on the continent. Three Jersey varieties were brought to flower at Mayagüez during the year and were crossed with various other varieties. These crosses will make possible varietal improvement in both major groups of sweetpotatoes—by introducing badly needed Fusarium-wilt resistance into the Jersey varieties, and by introducing superior setting and root characters into the moist-flesh varieties.

The horticulture group, in addition to initiating the cooperative cotton investigations, has completed important publications on tropical vines and shrubs. The entomologist also issued important publications on the coconut rhinoceros beetle and on *Cinchona* pests and their control.

PERSONNEL

The following changes occurred in the Federal Staff during the year: Thomas Theis was appointed plant pathologist on April 6, 1949. Roberto Ferrer Delgado was transferred from agronomist under insular funds to scientific aide under Federal funds.

There were several changes during the year in the personnel employed on funds provided by the Government of Puerto Rico. Filiberto Montalvo Durand was appointed to the position of agronomist on November 1, 1948. Héctor R. Cibes Viadé resigned as agronomist on November 30, 1948, to take graduate work at Rutgers University. The vacancy was filled by Felix A. Jiménez, appointed April 1, 1949.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The Government of Puerto Rico continued to support certain station activities. The Insular Legislature appropriated funds amounting to \$45,000 for the Federal Experiment Station to carry out cooperative experimental work on problems of particular interest to Puerto Rico, including investigations on vanilla, spices, weed control, essential oils, and bamboo.

The experiment station of the University of Puerto Rico and the Federal station continued close cooperation on agricultural problems. Exchange of information through conferences of the directors and members of the staffs of the two stations resulted in a well-coordinated program. Cooperative tomato- and papaya-improvement projects between the two stations were continued during the year. The Federal station provided office and laboratory space and land facilities for the experimental work with coffee being conducted at Mayagüez by the Insular station.

The College of Agriculture and Mechanic Arts of the University of Puerto Rico, located adjacent to the station, frequently utilized the station facilities in field demonstrations to students.

The extension service of the University of Puerto Rico cooperated with the station in the distribution of plant material, particularly tropical kudzu, bamboo, and USDA-34 sweet corn.

The Federal and Insular Forest Services made labor available to the station for the propagation and distribution of newly introduced bamboos. Several thousand offsets of bamboo were planted on watersheds throughout the mountainous areas of Puerto Rico. The Forest Service continued to make areas of land available at Toro Negro, Maricao, and Guánica, for the testing of various tropical plants and for the cinchona program of the station.

The Puerto Rican Industrial Development Company continued co-operation with the station through the distribution and sale of cured bamboo culms for industrial purposes.

The station cooperated with several bureaus and agencies of the Department. Three hundred and fifty-three lots of cottonseed collected from Guatemala, southern Mexico, and other foreign countries by the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Texas Agricultural Experiment Station were grown at four locations. These semiwild tropical and subtropical cottons, potential germ plasm for improving domestic varieties, flower and fruit only under greenhouse conditions in the United States, while under Puerto Rican conditions they flower and fruit profusely. J. O. Ware of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and T. R. Richmond and C. F. Lewis of the Texas station visited the Federal station during the fruiting season to observe and catalog the growth and fruiting characteristics of these cottons. A rubber investigation project was continued in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Office and laboratory space and land facilities were provided for the Soil Conservation Service, United States Department of Agriculture. Office and laboratory space and land facilities were furnished the new Research and Marketing Act Soil Erosion Control Project. Office space was also made available to the Farmers Home Administration and to Insular and Federal plant quarantine inspectors of the Bureau of Entomology and Plant Quarantine.

The Bureau of Plant Industry, Soils, and Agricultural Engineering, through its Division of Plant Exploration and Introduction, made available to the station a large quantity of plant material on an exchange basis.

Considerable quantities of planting material were sent to the Office of Foreign Agricultural Relations for introduction and testing at

their cooperative experiment stations throughout Latin America. A series of cooperative experiments was initiated in collaboration with the Complementary Crops Division, Technical Collaboration Branch, represented by F. A. McClure, field service consultant on bamboo for that agency. The objective of these experiments is the production of small plants for economy of transportation costs, propagating material, space, and labor.

The exchange of information on tropical crops between both organizations has been of mutual benefit.

The Mexican Government assigned an agronomist to work at the station for a period of approximately 5 months to study the work in progress on vanilla.

A considerable number of other institutions and agencies, as well as individuals, scattered throughout the tropical world, cooperated with the station in providing plant material to add to the extensive collection of tropical plants.

PHYSICAL-PLANT IMPROVEMENT

Reinforced concrete roofs were built under contract, on the front east and west office wings of the administration building, to replace old wooden and galvanized-iron construction. These offices were rewired and painted, and minor repairs were made in the ceilings of the lower rooms. Reinforced concrete porticos were also built around the patio of the main office and over the lower passage on the north side of the main building. A corrugated-zinc roof was constructed over the entomology office, and new wiring and outlets installed. An old tile roof over the bamboo shop, garage, and labor foreman's office was replaced with corrugated zinc.

The cooling chambers in the air-conditioned greenhouse were rebuilt, the instrument panels were rewired, and a new cooling unit installed.

Concrete curbs were built along part of the station's hard-surfaced roads, and an increased parking area for visitors and station personnel was developed.

A 750-gallon capacity water tank was installed on top of the new head house. Unchlorinated water with pH adjusted to 6.6-6.8 is pumped into the tank for use in watering plants in the greenhouse.

A fire-alarm siren, with push-button control, was installed on the roof of the administration building.

The plant-breeding greenhouse has been made insect-proof by covering it with a 16-mesh copper screen.

A seed-storage room, with temperature controlled at 50° C., was put into operation during the year. Adequate seed-storage facilities are now available for all needs of the station and for cooperating agencies.

INSECTICIDAL-CROP INVESTIGATIONS

DISTRIBUTION. R. H. Hageman

Seven thousand cuttings of *Derris elliptica* (Wall.) Benth. (Changi No. 3 MG clones) were sent to L. H. Narodny, Roseau, Dominica, British West Indies. This shipment consisted of 750 12-inch cuttings of each of the 9 MG clones. Half of these cuttings are to be used in a cooperative experiment to determine the effect of the trellising

on root yield and quality of *Derris* plants grown at two locales having marked differences in rainfall. The 9 clones are to be maintained separately, thus making it possible to evaluate the merits of these clones when grown under different environmental conditions.

A shipment of nine varieties of *Derris* was received from the East African Agricultural Research Institute, Amani, Tanganyika Territory, through the courtesy of P. J. Greenway. None of the plants survived shipment, however.

A group of *Derris* plants that had been held at the Glenn Dale (Md.) station of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Division of Plant Exploration and Introduction, for safekeeping during the war was transferred to this station.

DERRIS AGRONOMIC EXPERIMENTS. R. H. Hageman and C. Pagán

Derris from two agronomic experiments was harvested, and chemical and biological evaluation of the roots were completed.

One of the most tedious and costly operations in the commercial production of *Derris* is the manual digging of the roots. *Derris* plants were grown on three types of replicated plots: (1) Level ground that served as a control, (2) ridges that were 8 inches high, and (3) 16 inches high, in an attempt to determine what effect ridging would have on root yield, insecticidal constituents, and ease of harvesting. The root yields were essentially equal for all three types of plots. The chemical and biological toxicity of the roots decreased as the height of the ridge increased. It required from one-half to two-thirds the time to manually harvest the roots of the plants grown on the ridges as compared with those grown on the ground. From this experiment the practice of growing *Derris* on ridges cannot be recommended as an economical agronomic practice. Harvesting by plow was from three to four times faster than digging manually even on the 25-foot experimental rows. Plowing to an 8-inch depth recovered only 75 percent of the roots. A mechanical device that would turn over a 14- or 16-inch furrow would probably yield a higher percentage of the roots.¹

Nine high-quality Changi clones were introduced by the station in 1940. These clones were identified as MG (Mayagüez-Goodyear) and numbered from 1 to 9 in order of decreasing rotenone percentage obtained in a preliminary evaluation. The plants of the second evaluation trial were harvested in January 1948, 31 months after planting to the field in a well-replicated experiment, and evaluated for yield and toxicity. No significant differences were found in yield of roots among the nine clones, but clone 9 was highest in root production. Clones 1, 2, 3, and 4 were consistently better than the remaining clones with regard to quality of root, based on percentage rotenone. The average yield of rotenone for the nine clones accounted for about one-half the total toxicity, as determined by bio-assay. The best clones in the group, based on the amount of insect control per plant or per acre, were clones 1 and 9.²

¹ HAGEMAN, R. H., and PAGÁN, C. THE EFFECT OF RIDGING ON EASE OF HARVEST, ROOT DISTRIBUTION, AND TOXIC CONSTITUENTS OF DEBRIS ELLIPTICA. Trop. Agr. [Trinidad], [In press]; abs. in Agron. Jour. [In press].

² HAGEMAN, R. H., and PAGÁN, C. AN AGRONOMIC EVALUATION OF NINE MAYAGÜEZ-GOODYEAR (MG) CLONES OF DERRIS ELLIPTICA. Agron. Jour. 41: 440-442, illus. 1949.

TRELLISING DERRIS ELLIPTICA CHANGI No. 3 MG CLONES. R. H. Hageman
and C. Pagán

The MG clones of *Derris elliptica* var. Changi No. 3 grown at this station have long, bare, twining stems and generally lack foliage. These stems are at first erect, but as they grow longer they bend downward forming an arc with the tip reaching the ground. Shortly thereafter the apical section usually dies back to the top of the arc, and one or more of the axillary buds becomes dominant and the process is repeated. Usually the only leaves that are retained are on the erect portion of the main or branch stems. This type of growth should result in reduced yields of roots and rotenone. Preliminary experiments precluded nutrition and shade as contributing factors, and indicated that a more normal growth and leaf retention was obtained by trellising the shoots vertically. Another more comprehensive trellising experiment showed that trellising the young shoots vertically increased stem growth significantly and promoted leaf set and retention. On the other hand trellising the stems downward produced stunting, dieback, and loss of leaves. This latter type of trellising stimulated the natural growth habits and resulted in a similar type of injury. A cooperative experiment with a commercial grower is now under way to determine if vertical trellising is of agronomic importance. Applications of indolebutyric acid in concentrations ranging from 0.2 to 0.001 percent in a 50-percent alcohol solution produced injury and reduced stem growth.

CHEMICAL AND STATISTICAL STUDIES. C. Pagán and R. H. Hageman

Derris roots are sold on the basis of rotenone content, though this is not the best criterion of their insecticidal value. Other chemical values such as total chloroform extractives, red-color value, and transmission are obtained by simpler and faster procedures and are better indications of toxicity. Of these three methods, that of total chloroform extractives is the best in both rapidity and accuracy.

Statistical studies of *Derris* grown in Puerto Rico showed that there is a constant relationship between rotenone and total chloroform extractives for any given variety. A similar relationship between total chloroform extractives and toxicity (rotenone equivalent) determined by the guppy method has also been established. Regression equations were found to be the best means of showing these relationships because they do not give the exaggerated errors at the maximum and minimum values as is true with ratios. The regression equations for two commercial varieties, Changi No. 3 MG and Sarawak Creeping of *Derris elliptica*, obtained by analysis of the data of eight separate agronomic experiments covering a 5-year period were as follows³: Changi No. 3 MG, $R=0.41E-0.20$; Sarawak Creeping, $R=0.31E-0.39$. The regression equations for toxicity to total chloroform extractives for these two varieties were established from data obtained over a 2-year period. These were as follows: Changi No. 3 MG, $T=0.76E-0.27$; Sarawak Creeping, $T=0.48E+2.80$.

Five samples each of five varieties of *Derris* were analyzed for the Complementary Crops Division of the Office of Foreign Agri-

³ In these equations R =rotenone value; E =total chloroform extractives value; and T =toxicity expressed as rotenone equivalent.

cultural Relations who supervised the growing and harvesting of these plants in Nicaragua. Two of these varieties were identical with Changi No. 3 MG and Sarawak Creeping grown at this station and used to establish the foregoing regression equations. Rotenone content and toxicity of these samples were calculated from these equations and the actual total chloroform extractive values. The calculated rotenone percentage was 6.1 compared with 6.0 for the Changi No. 3 MG variety and 2.7 compared with 2.5 for the Sarawak Creeping. The toxicity values were in similar agreement. The calculated toxicity value, 12.4 percent, agreed closely with the actual assay value, 12.1 percent, for the Changi No. 3 MG. The calculated value for the Sarawak Creeping was 7.1 percent compared with the assay of 6.8.

These data indicate that there is a constant relationship of the toxic constituents within a given variety of *Derris elliptica* grown at two different locations. This relationship is probably due to generic factors and therefore should be constant for any given variety regardless of location.

ANALYSIS OF LONCHOCARPUS FROM PERU. C. Pagán and R. H. Hageman

At the request of the Office of Foreign Agricultural Relations, a complete chemical and biological analysis was made of three samples of *Lonchocarpus nicou* (Aubl.) DC. and two of *L. urucu* Killip & Smith. *L. urucu* is far more vigorous, has dark-colored foliage, and has a much heavier root system than does *L. nicou*. However, *L. nicou* was superior to *L. urucu* with respect to chemical values and toxicity. *L. nicou* had 5.8 percent rotenone, 14.4 percent red-color value, 16.3 percent total chloroform extractives, and 9.1 percent rotenone equivalent. The corresponding values for *L. urucu* were 1.3, 2.6, 3.2, and 1.9, respectively.

DRUG-CROP INVESTIGATIONS

FIELD STUDIES. H. F. Winters

Field planting of several *Cinchona* species was started in the western part of Toro Negro Forest in 1943. In subsequent years additional plantings were made, which included the more important cultivated strains of *Cinchona*. A summary of plantings to date shows that, in general, a low rate of survival indicates a high incidence of susceptibility in the strain to a root-rot disease presumably caused by a species of *Phytophthora*. However, some loss of plants has been due to wind damage.

Growth of the different strains varied from almost none, to extreme vigor. In the plot of 5-year old *Cinchona ledgeriana* Moens, from Maricao tree No. 24, many of the trees stand 15 feet tall and have a trunk diameter of 3 inches. Although this strain has performed better than many of the other strains, it is not entirely resistant to the disease. Survival has also varied in the 30 strains of *Cinchona* brought from the Philippine Islands by Col. Arthur F. Fischer. In this group the strains showing hybrid characters have made the most vigorous growth.

SEEDBED TREATMENTS. H. F. Winters

Damping-off causes considerable death of plants in *Cinchona* seedbeds. An experiment was conducted to compare the effects of media

and chloropicrin fumigation in controlling this disease. Growth data obtained from the experimental plots prior to transplanting seedlings to nursery beds showed that plants grown in pure sphagnum moss suffered from nutrient deficiencies. Some plants in this treatment grew fairly well, but most appeared stunted. With an average height of 3.67 cm., plants in these plots were larger than those grown in untreated soil. Plants in plots of untreated soil plus 1 inch of sphagnum grew uniformly well, but not as vigorously as those in plots of treated soil plus 1 inch of sphagnum. Plants in the latter treatment averaged 7.83 cm., which made the largest growth of all treatments. Plants in treated soil, alone, averaged only 4.03 cm. in height. The results of this experiment indicate that both chloropicrin treatment and covering the soil with sphagnum were beneficial in controlling damping-off.

FERTILIZER STUDIES. H. F. Winters and A. J. Loustalot

A field planting was made in November 1947 of *Cinchona* seedlings taken from a nursery experiment where they were grown with four levels of light and three levels of nitrogen. The experiment was continued in the field with three levels of nitrogen, in factorial arrangement with the previous three levels maintained in the nursery. One year after the plants were transplanted to the field a count of survival showed that an average of 12 plants, out of an original 15 per plot, survived. Variation between plots was slight. It was apparent that survival was not affected either by the nitrogen level maintained in the nursery or that applied to the plants in the field.

PHYSIOLOGICAL STUDIES. A. J. Loustalot and H. F. Winters

Cinchona seeds are planted in covered beds, and the plants are transplanted to shaded nursery beds when of sufficient size.⁴ Adjusting the plants to full sunlight is an extremely important phase of nursery management. An experiment was started in December 1947 to study the effect of light on the growth of *Cinchona* seedlings. The growth data obtained after 7 months of treatment showed that on the average the plants grown in reduced light were smaller and had less fresh and dry weight than did plants grown under the higher light level. This was true for both the *C. ledgeriana* and *C. succirubra*. Plants of the latter species were larger than those of *C. ledgeriana*, as would be expected.

The results of this study have practical applications in nursery work. At the time small *Cinchona* seedlings are transplanted from the seedbed to the nursery, it is necessary to protect them from wilting and direct sun by rather heavy shade. If the shading material is not partially removed as soon as the plants have recovered from transplanting, an unfavorable light condition is obtained, similar to that of this experiment. A high shoot-root ratio was obtained under condition of reduced light, which indicates that the rate of carbohydrate synthesis was probably very low because light was the limiting factor.

CHEMICAL STUDIES. A. J. Loustalot, C. Pagán, and H. F. Winters

An experiment was initiated in June 1946 to study the relationship between size, age, and parts of young *Cinchona* trees and their total

⁴ WINTERS, H. F. CINCHONA PROPAGATION. Puerto Rico (Mayagüez) Fed. Expt. Sta. Bul. [In preparation.]

alkaloid and quinine content. With some exceptions, the results of the 1948 analyses were similar to those of the two previous years. There was no consistent correlation between vigor, as measured by height of tree, with total alkaloids and quinine content.

The percentage of quinine in the roots and lower trunk bark ranged from 6.45 percent to 2.29 percent, and in the upper trunk bark from 2.43 percent to 0.58 percent. There was a tendency for the amount of quinine in the roots and upper trunk bark to be correlated with that in the lower trunk bark. The quinine content of all tissues was generally lower in 1948 than in 1947. The percentage of total alkaloids in the roots was correlated with that in the lower trunk bark and this was also true, but to a lesser extent, with the total alkaloids in the upper trunk bark. The percentage of total alkaloids was also lower in all tissues in 1948 than in 1947.

FOOD-CROP INVESTIGATIONS

TOMATO PRODUCTION. H. E. Warmke, H. J. Cruzado, R. M. Smith,⁵ and E. A. Telford⁵

An experiment was conducted to test the feasibility of producing vegetable crops on established, hand-cut terraces, using tropical kudzu to stabilize the banks. Tomatoes were grown without added organic matter, with filter press cake ("cachaza") worked into hills immediately before planting, and with the kudzu trash from the terraces worked into the hills immediately before planting. Plants with kudzu trash worked into the hills before planting were more vigorous and produced more marketable fruit than either the controls or the cachaza-treated plants. The addition of NH₄NO₃ improved the plant color and caused a slight increase in average yield in all treatments. Cachaza, a byproduct of sugar manufacture, is widely used as a soil amendment on the island, and its detrimental effect in this experiment was unexpected. A possible explanation was an outbreak of bacterial wilt to which the cachaza-treated plants seemed especially susceptible.

TOMATO BREEDING. H. E. Warmke and H. J. Cruzado

Forty-three Mayagüez selections from hybrids between native and imported tomato varieties, grown during the months of June to September, produced an average of over 2.5 times as much marketable fruit as did the standard varieties, Marglobe and Michigan State Forcing. The 10 best hybrids produced an average of 1.58 pounds per plant, or over 4 times the average of the imported varieties; and the best hybrid produced 2.10 pounds, or nearly 5 times as much as Marglobe, the best imported variety in these trials.

Stocks showing some resistance to bacterial wilt were selected and grown in a replicated experiment in a field known to be heavily infested with this organism. Yields from all lines in this field were very low (because of severe infection), but the Mayagüez selections outyielded all of the imported or native varieties. Further tests will be necessary to determine if this resistance is sufficient to make it of commercial value.

⁵Respectively, USDA Soil Conservation Service, and Bureau of Plant Industry, Soils, and Agricultural Engineering.

STEP TRIALS. H. J. Cruzado and H. E. Warmke

Four Mayagüez selections (48209, 48210, 48211, and 48212) from crosses involving native tomatoes were included, for purposes of comparison, in local replicated trials of the 1948 selections from the Southern Tomato Exchange Program (STEP), sponsored by the U. S. D. A. Regional Vegetable Breeding Laboratory at Charleston, S. C. The best Mayagüez line significantly outyielded all STEP selections. The four hybrids yielded an average of 33.61 ounces per plant, or over twice the average of all the STEP lines (15.71 ounces per plant). The average for the hybrids was nearly five times that of Rutgers and over twice that of Grothen Globe, in these trials. Line 48209, although yielding somewhat less than either 48210 or 48212, is relatively stable and has fruit of acceptable market quality. This line is sufficiently promising that it has been introduced into the 1949 STEP trials as STEP 136. It will thus be tested by some 3 dozen cooperators throughout the southern United States and in Hawaii during the coming year.

Twenty-four new introductions to the Southern Regional Tomato Trials (STEP Nos. 80-103, inclusive) were also tested in local observational trials this past season. Some of these combine large fruit size with high yield and will be used in further crosses.

SWEETPOTATO FLOWERING. H. E. Warmke and H. J. Cruzado

Three Jersey varieties (Orange Little Stem, Maryland Golden, and Yellow Jersey) and 17 moist-flesh varieties (including Introductions 153655, 153907, and 153909) have flowered in experimental plots. Only 3 varieties out of the total of 23 included this year have failed to flower; all of these are Jersey types, and include Red Jersey, Big Stem Jersey, and Vineland Bush, which have made extremely poor growth.

Some of the common moist-flesh varieties, including B-5928, UPR-3, and Mameya, which began flowering last November, did not return to a vegetative state at the end of the usual flowering period. These varieties have flowered throughout the year. Original plants of the Jersey-type variety, Orange Little Stem, which flowered from early December until the middle of January last season, began to flower early in August and continued through the current season. None of the spring and summer blossoms appear to be as fertile, however, as those produced during the winter season.

SWEETPOTATO BREEDING. H. J. Cruzado and H. E. Warmke

Over 2,000 crosses were made during the past season as part of the sweetpotato improvement project started last year in cooperation with the Division of Vegetable Crops and Diseases of the Bureau of Plant Industry, Soils, and Agricultural Engineering.⁶ From these crosses, 227 fruits were set (10.28 percent), which contained a total of 337 seeds (15.62 percent). This is a considerable improvement over last year's results, where 23 fruits (3.6 percent) and 24 seeds (3.7 percent) were obtained from 645 crosses.

Older and more vigorous plants and an improvement in technique (starting crosses at 7:00 a. m.) probably were responsible for the

⁶ WARMKE, H. E., and CRUZADO, H. J. OBSERVATIONS ON FLOWERING AND FERTILITY IN SOME VARIETIES OF JERSEY AND MOIST-FLESH SWEETPOTATOES. Amer. Soc. Hort. Sci. Proc. [In preparation.]

higher percentages of fruits and seeds obtained this year. Crosses this year included two new Jersey varieties (Yellow Jersey and Maryland Golden), and the new Fusarium-resistant, moist-flesh types (Introductions 153655, 153907, and 153909).

Of the 337 hybrid seeds produced this year, 116 are from crosses between Jersey and moist-flesh varieties; 12 with a Jersey variety as the female parent and 104 with a Jersey variety as the male parent. Although a scarcity of flowers limited the number of crosses that could be made with Maryland Golden and Yellow Jersey these varieties appear to be more fertile than Orange Little Stem. The Jersey varieties, as a whole, set 11.21 seeds per 100 crosses when used as the female parent and 7.26 seeds per 100 crosses when used as the male parent. Among the moist-flesh varieties, Introductions 153907 and 153909 proved to be exceptionally fertile as females, with seed-sets of 30.38 percent and 21.97 percent, respectively. The native varieties, Mameya and Toro Negro Wild, were highly fertile as male parents, with seed-set percentages of 36.58 and 42.86, respectively. No seeds were obtained from a limited number of crosses with the varieties L-138, Queen Mary, and UPR-3.

The moist-flesh varieties, as a group, set 15.46 seeds per 100 crosses when used as a female and 29.99 seeds per 100 crosses when used as a male. Setting was poor at the beginning and at the end of the season (October–November, and the last part of March) and high during the middle of the season (January 16 to February 15). During the first 15 days of February, an average of 41.20 seeds were obtained for each 100 crosses. Numerous tests on emasculation and crossing techniques were carried out during the early part of the season. These tests indicate considerable cross-fertility, a high degree of self-sterility, a detrimental effect of bags for protection against insects, and that emasculation and protection techniques used were safe, and the emasculated flower (with petals removed) has little attraction for insects.

PAPAYA TRIALS. H. E. Warmke and H. J. Cruzado

Forty-four different varieties and introductions of papaya, *Carica papaya* L., coming from widely separated locations in the West Indies, South and Central America, Florida, Africa, and the Hawaiian Islands have proved susceptible to the destructive virus disease, "bunchy-top," in experimental plantings in Puerto Rico. At the end of 21 months no single line had escaped infection with the disease, and most of the plants were killed in plots at Mayagüez and Isabela. The few remaining healthy plants are to be experimentally infected with the virus to determine whether they are genetically resistant individuals, or only chance escapes from infection. Many valuable genes for fruit size, shape and quality, growth habits, and setting characteristics have been discovered in these stocks. Plants of the related species, *Carica gaudotiana*, *C. monoica*, *Jacaratia hassleriana*, and *J. dodecaphylla* have not exhibited symptoms of the disease in field plots, and some of these may possess true resistance.

MANGO TRANSPLANTING STUDIES. E. P. Hume and N. Almeyda

An experiment was conducted to determine the effect of various pruning methods and root treatments on the survival and subsequent growth of transplanted mangos, *Mangifera indica* L. The plants were dug, subjected to the treatments, and carried by truck and

schooner to the experiment station at St. Croix, U. S. Virgin Islands, and were out of the ground about a week.

During this process the plants were handled at least six times. Balled plants gave the highest percentage of survival (55 percent) if the leaves or top were removed. Even if a few top leaves were left on the plants' survival was reduced considerably. Trees transported with bare root stock survived surprisingly well (46 percent), considering the rough treatment they received. Dipping the roots in lanolin, glycerine, or mud suspension was of no apparent value. Although higher percentages of survival were obtained with topped or defoliated balled trees, the cost of digging and transporting was considerably greater. Balled trees weighed from 25 to 40 pounds each, but topped, bare root trees wrapped in coco peat weighed only about one-tenth as much. The time required to dig the latter was about one-sixth that of the balled trees.

ROOTING OF MANGO AIR LAYERS. E. P. Hume

A previous mango air-layering experiment, using plant hormones mixed with expanded mica, gave good initial rooting. However, the media remained quite dry during the rooting period. Another experiment was conducted using coco peat treated with various concentrations of indolebutyric acid in place of expanded mica. The coco peat layers were wrapped with pliofilm to prevent drying out as in the earlier experiment. After 90 days, during which 20 inches of rain fell chiefly in the form of heavy showers, the girdled branches were cut and examined. The coco peat had a much higher moisture content than at the start of the experiment and, as a result, a number of the roots had turned black. The living bark, especially at the lower hormone concentrations, had developed considerable proliferation of the lenticels. Rooting in general was poorer than in the previous experiment, using expanded mica and conducted during the dry season. The highest concentration, 1,000 p. p. m., was toxic, killing both phloem and outer xylem in some cases. Roots 2 inches or more in length were found only in the 100- and 400-p. p. m. treatments.

MANGOSTEEN STUDIES. A. J. Loustalot and E. P. Hume

The insertion of toothpicks impregnated with 4 mg. of indolebutyric acid in the stem of mangosteen, *Garcinia mangostana* L., seedlings, 1 inch above the crown, resulted in abnormal proliferation of roots in the treated area but top growth was reduced. It was expected that the treated plants might grow more rapidly during the second year because of the greater root system. Top growth measurement taken at the end of 2 years failed to show significantly greater growth by the treated plants. The treated plants had an abundance of new roots which were soft and more succulent than those on untreated plants. Many of them were destroyed as a result of attacks by insects and diseases. Thus, while the hormone treatment stimulated root development it actually operated to the disadvantage of the plant growth in general. The root hormone treatment as applied in this experiment was too strong because it overstimulated root formation at the expense of top growth.

PLANT INTRODUCTION AND PROPAGATION

DISTRIBUTIONS. E. P. Hume, N. Almeyda, and others

Most of the 469 packets of seed distributed were ornamentals, representing 361 species, and were sent to 45 countries and 8 states. The local distribution of plants totaled 14,313. A total of 114 square feet of Manila grass, *Zoysia matrella* (L.) Merr., was distributed in small lots. A collection of 8 varieties of yams, *Dioscorea* spp., and yautias, *Xanthosoma* spp., was sent to Centro Nacional de Agronomia de El Salvador. The distribution of sweet corn var. USDA-34 amounted to 59 pounds. Ten pounds of seed pieces of Chinese ginger were also distributed. A total of 166 pounds of tropical kudzu seed was distributed to 28 different countries. Eighteen Latin-American countries requested seed of this tropical legume, Cuba being the highest with 11 requests. Thirty-eight requests were received from native farmers.

INTRODUCTIONS. E. P. Hume, N. Almeyda, and others

Two hundred and ninety introductions were received from thirty countries. These consisted of: Ornamentals, vegetables, fruits, cover crops, tobacco, and bamboo. One of the most interesting of the new introductions is the cocona, *Solanum hyporhodium*, recently publicized by the Institute of Agricultural Sciences, Turrialba, Costa Rica, as a fruit for preserving, pies, and sauces.

A number of species of legumes were introduced from Australia for testing and for use in the plant breeding program at the station. The Bureau of Plant Industry, Soils, and Agricultural Engineering sent two bamboo species: *Semiarundinaria fastuosa*, P. I. 112080, and *Schizostachyum funghomii*. Five papaya species were also received. Fifteen strawberry varieties were received from Maryland and 10 sorghum varieties from Arizona.

The *Lansium domesticum* Jack., a small tree, is prized by the people of the Far East for its fruit. A heavy crop was produced in November and sampled by members of the station staff. This translucent, mildly flavored fruit met with reactions varying from worthless to delicious. Apparently it would require considerable cultivation of the taste before the fruit would become generally accepted.

During the past 2 years a general survey of the woody plants in the station collection has been in progress. Whenever time was available the plants have been examined and located on a field map. This map is divided into quadrants 500 feet square. Permanent concrete markers have been placed at the quadrant boundaries, to facilitate locating the plants. A card index has also been prepared listing all known species and the quadrants in which they are growing.

MANGO BUD TREATMENTS. E. P. Hume

An experiment was carried out to determine the possibility of inducing growth of dormant axillary buds of mango, *Mangifera indica* L., by treating them with concentrations of nicotinamide in concentrations varying from 50 to 50,000 p. p. m. The petioles treated with water, 50, and 500 p. p. m. of nicotinamide abscissed in 7 to 10 days, the normal time when the leaf blades are cut off. No injury was observed from any of these treatments.

The 5,000-p. p. m. treatments caused delayed abscission with uneven, somewhat blackened leaf scars. The petioles had a water-soaked appearance but no damage was observed in the phloem or xylem. The highest concentration, 50,000 p. p. m., prevented abscission but the petioles rotted and eventually fell off. The injury penetrated into the xylem almost to the center of the stem and extended 1 to 2 inches above the point of attachment and $\frac{1}{2}$ to 1 inch below, in a narrow strip. One to 3 leaves directly above the treated petioles also died, and a small area directly under their points of attachment blackened. Both the xylem and phloem between these injured areas were apparently undamaged. These disconnected, injured areas were always directly above the treated petiole. Apparently there was local concentration of the applied chemical substance only at the leaf base directly above the point of application.

MANILA GRASS SEED GERMINATION. R. H. Hageman

Germination tests were made of Manila grass seed harvested at 2-week intervals over a period of 2 months beginning February 10. The highest yield of viable seed was obtained from the initial harvest date. Of the seed collected on this date 12.9 percent were well filled or "heavy," and of these 17.2 percent germinated. The germination of the total seed collected during the entire season was less than 1 percent, which is in agreement with previous trials.

ENTOMOLOGY

DDT TRIALS. H. K. Plank and R. Ferrer Delgado

In a previous experiment it was shown that dipping bamboo for 10 minutes in a 5-percent solution of DDT in Diesel fuel oil maintained almost complete control of the bamboo powder-post beetle (*Dinoderus minutus* (F.)) for 3 months. Examinations for external evidences of internodal infestation were continued at intervals of 3 months for 1 year to determine the lasting qualities of this treatment. The Diesel fuel solvent alone produced a small amount of control, significant only during the first 6 months after application on clump-cured material. The 5-percent DDT solution produced a highly significant degree of control that lasted for 12 months on both freshly harvested and clump-cured material, but this control tended to be more permanent on the freshly harvested culms: From 98 percent on both kinds of bamboo at 3 months the control decreased to 91 percent on the freshly harvested and to 88 percent on the clump-cured at 12 months after treatment. When split open at the 12-month examination all of the 300 internodes in the untreated freshly harvested culms, and all but 5 in the clump-cured culms, were found attacked by the beetle. Most of the former were riddled, whereas those that had been clump-cured were lightly damaged.

Where DDT was applied, the control was still 91 percent in the freshly harvested culms, but 79 percent in the clump-cured culms, with the difference in number of damaged internodes being statistically significant. Apparently no improvement in control of internodal infestation is to be derived from previously drying the culms, as in clump-curing, before dipping in DDT. The residue left by the DDT treatment was still visible on some of the culms at 12 months after treatment. Ring sections from both freshly harvested and

clump-cured bamboo dipped separately in the same solution and exposed continuously to beetle infestation were still uninfested when this last examination was made.⁷

BAMBOO SUSCEPTIBILITY. H. K. Plank and R. Ferrer Delgado

A comparison as regards susceptibility to attack of the bamboo powder-post beetle was completed with culms of 5 different ages of the large-leaved variety, *Dendrocalamus strictus* Nees, and *Bambusa vulgaris* Schrad. ex Wendl. The over-all susceptibility of *D. strictus* was 18.0 percent. As in previous tests, the first-year growth of *B. vulgaris* tended to be more heavily infested than that of later ages. With *D. strictus* the tendency was the reverse, in this respect resembling *Sinocalamus oldhami* (Munro) McClure. In *B. vulgaris* there occurred the usual trend for the base of the culms of all ages to be more heavily infested than the middle, and the middle more than the top. However, in the fifth-year culms the middle part was attacked the most. This latter condition also maintained in all ages of *D. strictus* except the second, but the number of beetle attacks was too small for the differences between parts to be significant within any one age. In *B. vulgaris* there was also the usual tendency for starch concentration to decrease with age, but in *D. strictus* it increased in all culms of successive ages except the third. This association of starch concentration with beetle infestation corresponds closely with that previously shown for the same ages of *B. vulgaris* and *S. oldhami*.

Unlike other species low in starch, *Dendrocalamus strictus* showed no correlation, at any of the ages tested, between beetle attack and high moisture content and low specific gravity of the wood. Neither was there any correlation between beetle attack and shrinkage in volume of the wood on drying. In spite of the fact that the fifth-year growth contained less moisture, was heavier, and shrank less on drying than the first-year wood, it was attacked more by the beetle. This inconsistency was no doubt due to uneven distribution of what little starch was present and the consequent irregular variation in small numbers of beetle attacks.

SOIL-EROSION CONTROL AND STABLE CROP PRODUCTION IN PUERTO RICO⁸

LEGUME EVALUATION. R. H. Freyre and H. E. Warmke

The experiment established last year for comparing the relative forage production and nitrogen fixation of five legume-grass combinations has been carried through four harvests in the south field and three in the rubber field. On the basis of yields to date certain trends are evident. In the south field, grass-legume combinations are producing significantly more forage than either grass or legumes alone. Under the poor conditions of soil and moisture and partial shading which exist in the rubber field, competition between the grass and legumes appears to be reducing total yields in grass-legume combinations. Vigorous and long-lived legumes, such as tropical kudzu

⁷ PLANK, H. K., and FERRER DELGADO, R. PERMANENCE OF DDT IN POWDER-POST BEETLE CONTROL IN BAMBOO. Jour. Econ. Ent. [In press.]

⁸ A Research and Marketing Act Project in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Soil Conservation Service, and the Experiment Station of the University of Puerto Rico.

and red bean, are superior to less vigorous perennials or to annual legumes, such as cowpea and Florida velvetbean. In the rubber field, the application of ammonium sulfate to grass plots seems to be more practical, to date, than the use of grass-legume combinations in increasing forage yields.

Test plots of 131 introduced and native legumes have been established. The purpose of these plots is to study some of the legume characteristics, including (1) type of growth, (2) whether annual or perennial, (3) flowering season, (4) seeding, (5) disease and insect incidence, and (6) adaptation to climate. Most of the species have already flowered and seeded. Among those showing promise under the plot conditions are *Crotalaria paulina*, *C. usaramoensis*, *Canavalia ensiformis*, *C. bonariensis*, and certain varieties of *Dolichos lablab* and *Cajanus indicus*. A group of 6 alfalfa strains made good early growth but subsequently have not developed well. Three species of *Lespedeza* and the 10 strains of *Lupinus*, as well as one species each of *Vicia*, *Onobrychis*, and *Trifolium* did not survive the conditions in the south field.

FORAGE QUALITY. R. H. Freyre, R. Fernández Pol, and H. E. Warmke

Preliminary results of chemical analyses of Merker grass from grass-legume plots show that the percentage of nitrogen and total yield of crude protein are increased when Merker grass is grown in combination with legumes, as compared with Merker grass grown alone. These analyses also indicate that grass grown in combination with legumes may be richer in the important minerals, calcium, magnesium, potassium, and phosphorus.

LEGUME BREEDING. R. H. Freyre and H. E. Warmke

Interspecific hybrids from crosses between *Stizolobium deeringianum* Bort. (Florida velvetbean), *S. aterrimum* Piper and Tracy (Bengal bean), and *S. pruritum* (Wight) Piper and Tracy (pica pica) were studied as to the mode of inheritance of certain genetic characters. These studies indicate that the hairiness on leaves and stems and the obnoxious stinging hairs of the pica pica pods are largely dominant over their alleles in the other two species, with the degree of hairiness varying somewhat in different crosses. Hairy pods with glabrous leaves and stems were obtained in one case when two hairless velvetbean varieties were intercrossed, thus suggesting that hairiness on pods and on leaves and stems are independent characters and that pod hairiness may be the result of complementary action. The black color of the Bengal bean seed is dominant over the mottled condition in the other species. An intermediate amount of speckling was obtained when two varieties varying in degree of speckling were crossed. Shape and size of seed are also probably determined by genetic factors, seeds in the F_1 having the tendency to be intermediate between parents.

Entire plants of tropical kudzu, when covered with cages of copper screen, set very few seed pods, while unprotected control plants set abundant pods. Since the keel in kudzu flowers appears to open only rarely so as to expose the stigma before the blossom falls, this species was assumed to be largely self-pollinated. The high degree of sterility under the cages, therefore, was unexpected. Experiments are planned to determine whether the failure of seed setting under the

cages is due to a true self-sterility, to a mechanical failure in pollination, or perhaps to some slight change in environment caused by the screens.

GRASS STUDIES. H. E. Warmke and Elida Vivas

Studies on field-grown plants of regular guinea grass (*Panicum maximum* Jacq.) and four of its varieties, gramalote, coarse-leaf, fine-leaf, and Borinquen, indicate that a large majority of the seeds which fall early from an inflorescence are empty and valueless. Filled seeds are retained on the plants and are not shed in any quantity until the thirteenth day after the beginning of anthesis in an inflorescence. For these varieties, as a group, 59.4 percent of the total empty caryopses are shed by the twelfth day, while only 8.3 percent of the total full ones have shed by this time. The data obtained also indicate that the percentages of filled seed produced by this group of grasses is relatively high: Gramalote 56.37 percent, fine-leaf 50.71, coarse-leaf 36.50, guinea 28.60, and Borinquen 6.47 percent.

This information is of considerable practical value in commercial harvesting of seeds of these grasses. Samples of seed furnished by two commercial producers on the island appeared very immature and have been found to contain less than 1 percent of filled seeds. The above data would suggest that this seed had been harvested during the shedding of the empty caryopses, and before the filled ones had time to mature.

During studies on techniques of emasculation, it was found that these same grasses show striking differences in time and rate of anthesis. The anthers and stigmas of fine-leaf guinea begin to emerge in the late afternoon, continue through a maximum at 6:30 p. m., and finish about 11:15 p. m. The varieties coarse-leaf, regular guinea, and gramalote come in this order, with maxima at 9:15 p. m., 12:45 a. m., and 2:30 a. m., respectively. The duration of anthesis in addition to the hour is also variable, requiring approximately $7\frac{1}{2}$ hours for completion in the fine-leaf variety, and approximately $2\frac{1}{2}$ hours in gramalote. These differences in anthesis, although affected to some degree by temperature and perhaps other environmental factors, are surprisingly constant, and it is believed they represent true differences in physiological reaction patterns among these grasses.

PASTURE IMPROVEMENT. E. A. Telford, R. M. Smith, and C. F. Cernuda⁹

All essential details were carried out for the establishment of about 10 acres of improved kudzu-grass pasture to be used in pasture management studies. Most of the procedures necessary for successful pasture-management studies were devised and put to a practical test. During the rainy season the pastures carried one animal unit or more per acre without any cut forage. Pastures without lime and fertilizer were inferior to the LP- and LPK-treated pastures, but no benefit was shown for K. Total dry forage produced per day from August to January ranged from 42 to 75 pounds on the treated pastures, according to repeated square-yard harvests. The percentage of protein in the concentrate was reduced from 20 percent to 15 percent with no influence on milk production trends.

⁹With USDA Bureau of Plant Industry, Soils, and Agricultural Engineering; BPISAE and Soil Conservation Service; and SCS, respectively.

Surface treatment of native pasture with L, P, LP, LPK, and LPKN showed significant response during the first year only to the LPKN treatment. This response was evident in percentage of ground covered, percentage of desirable grasses, and in total herbage yield. The best yield, however, was only about one-third of the yield of improved kudzu-grass pasture for comparable periods.

SOIL STUDIES. D. K. Fuhriman, C. F. Cernuda, J. R. Hernández, E. A. Telford, and R. M. Smith¹⁰

General soils studies showed some of the major variations with depth in soil profiles and with location on the island. The relatively high organic matter contents of tropical soils was measured and confirmed and some evidence was obtained as to the relatively rapid build-up of organic matter which is possible.

Practical studies on steep Utuado soil showed that much of the soil loss downhill is due to tillage and gravity. Artificially flattened benches proved to be quite productive when properly treated and managed. Steep hillside plots showed that some erosion control can be obtained with trashy culture, but many management details must be carefully considered.

A survey of the efficiency of the methods of water used in Puerto Rico was initiated and considerable data were accumulated. These data show that efficiencies generally are low and that in most cases less than 50 percent of the water applied is being utilized by growing crops.

Various items of soil physics equipment were tested under tropical soil and water conditions to determine their usefulness.

ESTABLISHING A COOPERATIVE NATIONAL RESEARCH PROGRAM TO DEVELOP PRACTICAL METHODS AND EQUIPMENT FOR WEED CONTROL¹¹

PERSISTENCE OF SODIUM PENTACHLOROPHENATE. A. J. Loustalot and R. Ferrer Delgado

Sodium pentachlorophenate is a promising herbicide in pre-emergence weed control treatments. Experiments were conducted to study the effect of temperature, soil moisture, texture, and other environmental factors on persistence of sodium pentachlorophenate in the soil.

The data obtained in the temperature study showed that the toxicity of sodium pentachlorophenate decreased with the passage of time, as measured by the growth of corn and cucumber in treated soil. The rate and degree of inactivation was greater at the warm temperature than at the cold. As would be expected, the toxicity persisted longer at the higher rates of application. Toxicity of the herbicide at the lowest rate of application persisted for at least 2 months when the soil was stored at 10° C. The growth of corn and cucumbers in treated plots stored at this temperature was the poorest of all the treatments. There was some indication that the toxicity of the penachlorophenate

¹⁰ Fuhriman and Cernuda with USDA Soil Conservation Service; Hernández and Telford with Bureau of Plant Industry, Soils, and Agricultural Engineering; and Smith with BPISAE and SCS.

¹¹ A Research and Marketing Act project in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

increased rather than decreased with the passage of time at the low temperature. The cucumbers were affected to a greater extent by the pentachlorophenate than the corn, possibly because the corn has a larger seed.

In plots treated with 90 or 60 pounds per acre, the cucumber seed either failed to germinate or, if they did germinate, grew very poorly. The results of this experiment, insofar as they are applicable to field conditions, indicate that prolonged toxic effects of sodium pentachlorophenate would be expected during cold weather. They also indicate that higher rates of application can be made with greater safety in warm weather than in cool.¹² The data obtained in the soil-moisture study indicated that the toxicity of sodium pentachlorophenate was not reduced any appreciable extent with the passage of time when applied to air-dry soil. The toxicity of the herbicide persisted somewhat longer in soil that contained a medium moisture level than in saturated soil. The toxicity had almost completely disappeared at all levels of application after 1 month in saturated soil; whereas 2 months were required for the toxicity to disappear in soil with a medium moisture content.

The results obtained in the soil-texture study showed that the toxicity of sodium chlorophenate persisted for a longer period of time when applied to heavy clay soil than when applied to sandy soil or sandy-clay mixture. One month after application there was no appreciable reduction of toxicity of the herbicide in the clay soil. The reduction in toxicity in the sand-clay mixture was more or less the same as in the sandy soil. The toxicity of sodium pentachlorophenate was reduced at about the same rate in autoclaved soil as in unautoclaved soil.

Preliminary analysis of plants treated with 2, 4-D showed a higher concentration of inorganic phosphates in treated plants than in untreated ones.

WEED CONTROL. A. J. Loustalot and R. Ferrer Delgado

The effect of six pre-emergence weed-control treatments on yield of USDA-34 sweet corn was tested in a Latin square design. The results indicated that USDA-34 field corn can be grown successfully without cultivation in Puerto Rico by using Sinox at 12 gallons per acre plus 2.6 pounds of butyl 2, 4-D or Santobrite at 43 pounds per acre as a pre-emergence treatment. The latter treatment is preferred because of lower cost.

Considerable mechanical weeding is frequently necessary to establish a planting of tropical kudzu from seed. An experiment was conducted to determine if pre-emergence weed control treatments with Santobrite would enable a planting of tropical kudzu to be established without mechanical weeding. Santobrite in aqueous solution was applied to planted plots in a replicated experiment at the rate of 0, 20, 40, and 60 pounds per acre. The results indicated that a good stand of tropical kudzu can be obtained in a relatively short time, without mechanical weeding, by using Santobrite at the rate of 20 to 40 pounds per acre as a pre-emergence weed control treatment. The 60-pound rate was injurious to the kudzu seed.

¹² LOUSTALOT, A. J., and FERRER DELGADO, R. THE EFFECT OF TEMPERATURE ON THE PERSISTENCE OF SODIUM PENTACHLOROPHENATE IN THE SOIL. In South. Weed Conf. Proc. La. State Univ., Baton Rouge, La., pp. 55-58. Jan. 31-Feb. 2, 1949.

An experiment was conducted to test repeated applications of the most promising herbicides in controlling nutgrass. The following treatments were applied to replicated plots: (1) Santobrite at 60 pounds per acre alone, and (2) with 5 pounds of sodium 2,4-D; (3) Santobrite at 60 pounds per acre alone, and (4) with 10 pounds of sodium 2,4-D; (5) sodium 2,4-D alone at 5 pounds per acre, and (6) at 10 pounds per acre; (7) Sinox A at 12 gallons per acre, and (8) Sinox AE at 12 gallons per acre. The results indicated that Santobrite at 30 pounds per acre and 2,4-D at 5 pounds per acre, applied three times at monthly intervals, was effective in controlling a heavy infestation of nutgrass under conditions of high rainfall. The experiment also showed that under these conditions the suppression of one weed pest, such as nutgrass, resulted in the substitution of another weed pest, Bermuda grass.

A combination of 2,4-D, tillage, and smother crop was tested to control nutgrass. Repeated applications of 2,4-D at 2.6 lb. per acre and tillage were ineffective. However, it was found that areas heavily infested with nutgrass can be used successfully for growing vigorous leguminous cover crops, such as velvetbeans, without mechanical or chemical weed control. The legume seed planted in the nutgrass germinated and grew vigorously when adequate soil moisture was available. The legume did not eradicate the weed pest but competed successfully by shading out and temporarily suppressing it.

In previous preemergence weed-control experiments there was some indication that the effectiveness of the herbicide was increased if it was applied several days after the land was plowed and prepared for planting. An experiment was conducted in which 2,4-D and Santobrite were applied at intervals of 2, 5, 9, and 16 days after plowing. The data obtained showed that both 2,4-D and Santobrite controlled weeds most effectively when applied as a preemergence spray 9 days after the land had been plowed. Earlier or later applications gave less efficient control of weeds, under the conditions of this experiment. These results indicate that sufficient time should be allowed after plowing for weed seed and vegetative parts to start growth before the herbicide is applied.

In cooperation with a local sugarcane grower, test trials of the herbicidal combination of Santobrite at 30 pounds and 2,4-D at 5 pounds per acre were made in a newly planted canefield. The results of these preemergence weed-control trials indicate that weed competition in newly planted canefields can be reduced to a minimum for a period of 2 months or longer without mechanical cultivation. Weeds are controlled before they have a chance to compete with the young cane.

An experiment was conducted during the rainy season to compare 12 preemergence weed-control treatments in newly planted sugarcane. The following treatments were applied to four replications of $\frac{1}{40}$ -acre plots: 2,4-D as the acid and as the sodium salt at 1.3, 2.6, and 5.6 pounds per acre; Santobrite at 21.5, 43.0, and 64.5 pounds per acre; Dow Contact at 12 gallons per acre; Santobrite at 43 pounds, combined with sodium, 2,4-D at 2.6 pounds per acre; and, check. Four weeks after the treatments were applied all weeds, with the exception of nutgrass, were controlled satisfactorily except in the check and the Dow Contact plots. The plots treated with 2,4-D even at

the low rate, had somewhat better weed control than those sprayed with Santobrite. The low rate of Santobrite seemed to be as effective in controlling weeds as the highest rate. Likewise, there was no apparent difference in weed control between the high and low rate of 2,4-D, nor was there any noticeable difference in weed suppression between the acid and the salt. Since the experiment was conducted during the rainy season the acid was expected to persist longer, because it is much less soluble than the salt.

The germination of the sugarcane was affected to a certain extent by the 2,4-D, the effect being more pronounced at the higher rate. At the lower rate about 5 percent of the seed pieces failed to grow, and 12 percent failed to grow at the higher rate. Santobrite at the highest rate had no deleterious effect on cane growth. The results of this preemergence weed-control experiment indicate that satisfactory and economical control of weeds, except nutgrass, can be obtained without hand cultivation for a period of 6 weeks to 2 months after the cane is planted.

Sodium pentachlorophenate, sodium trichloroacetate (STA), and the sodium salt of 2,4-dichlorophenoxyacetic acid, alone, and in combination were tested for eradicating grasses and annual weeds. Four weeks after application all treated plots were relatively free of weeds, especially those treated with STA. The 100-pound rate of STA was as effective in suppressing the weeds as the 200-pound rate during the initial period. Also, there was no appreciable difference between plots sprayed with STA + 2,4-D and those sprayed with STA alone. The results to date indicate that sodium trichloroacetate is effective in controlling the hard-to-eradicate perennial grasses like Bermuda and Para. They also indicate that two applications at the rate of 100 pounds per acre are more effective than one application of 200 pounds per acre.

VANILLA

AGRONOMIC STUDIES. H. R. Cibes and A. J. Loustalot

In the third year of production, vanilla under a lath-shade experiment yielded 495 pounds of green beans per acre; although more than three-fourths of the plants were wilted or dead as a result of disease. The highest mortality occurred in beds with Catalina and Toa mulch, while beds with Soller mulch showed the least damage. The best root development was also obtained in Soller mulch. This experiment demonstrates that vanilla can be grown successfully under lath-shade conditions, but the vines must be maintained separately. The vegetative growth was thrifty beyond all expectation, and this was conducive to the spread of disease. A management experiment now in progress is designed to correct this difficulty.

An experiment was carried out to determine the effect of removal of old mulch and the application of fresh mulch at specific intervals on the growth of vanilla.

The growth data obtained 12 months after planting showed that the control treatment, in which mulch was not removed nor renewed, surpassed the other treatments both in vegetative growth and in the least amount of rotting of seed pieces. Root germination in this treatment ranked second to the treatment in which mulch was removed and renewed every 9 months.

The vegetative growth in the four treatments in which mulch was removed and renewed every 3, 6, and 9 months, plus the control where it was not renewed at all, was 136.47 feet, 133.75, 158.00, and 174.92 feet, respectively. This experiment demonstrates that removal of mulch is detrimental rather than beneficial. Mulch should be replaced rather than removed as it decomposes.

VANILLA HYBRIDS. H. J. Cruzado and A. J. Loustalot

Seed of crosses between *Vanilla fragrans* (Salisb.) Ames × *V. phaeantha* Reichb. f. were germinated at Cornell University by Dr. Lewis Knudson in January 1947 and sent to this station for propagation. They were grown in 3-inch pots in the greenhouse until October 1948, when they were of sufficient size for transplanting to the field. Of a total of 40 hybrids, 37 were transplanted to a lath-shade house, and most of these are making good growth. Because of the resistance of the *V. phaeantha* parent to vanilla root rot and drought it is hoped that these characteristics, along with good fruit quality, will be carried over into the hybrids.

PHYSIOLOGICAL EXPERIMENTS. A. J. Loustalot and H. R. Cibes

Vanilla vines were grown in two gravel culture experiments: One with three levels of nitrogen (3, 10, and 81 p. p. m.) and three levels of potassium (0, 7, and 40 p. p. m.), and the other with 3, 27, and 81 p. p. m. of nitrogen and 0, 5, and 27 p. p. m. of phosphorus in factorial combinations. The low level of nitrogen in both experiments had a profound depressing effect on growth. The low potassium level had depressing effect on growth, but to a lesser extent than nitrogen. An increase in the level of either N or K resulted in an increase in the growth of the vines. The best growth was obtained with the highest N-K level.

The N and K contents of the vines were directly correlated with levels at which these elements were supplied. The percentage of Ca and Mg in the leaves was inversely correlated with the potassium content. The low phosphorus level depressed growth primarily when nitrogen was low. The nitrogen and phosphorus contents of the vines was directly correlated with the levels at which these elements were applied. At all nitrogen levels the percentage of nitrogen in the leaves decreased as the phosphorus percentage (or supply) increased.

VANILLA CURING. C. F. Cernuda and R. Fernández Pol

An experiment was conducted to determine the effect of various oxygen levels during conditioning on the quality of cured vanilla. Oxygen equivalents of 20, 15, 10, 5, and 0 percent were established in bottles containing the vanilla beans for conditioning. Extracts from the various treatments were tested in milk.

It was found that extracts made from the vanilla conditioned at the 20 percent O₂ level in all three ages of conditioning gave the best flavor, followed by those conditioned at 15 percent O₂ level. No difference could be detected between the extracts made from beans conditioned with 10 and 5 percent O₂. The samples conditioned at zero O₂ made the poorest extracts. The vanillin in the samples stored at 0, 5, and 10 percent oxygen increased with the conditioning time. The percent vanillin for the samples stored with 15 and 20 percent oxygen was the highest when the conditioning time was 3½ months.

ESSENTIAL OILS

HARVESTING CITRONELLA AND LEMONGRASS. A. J. Loustalot and R. Fernández Pol

The West Indian and Java varieties of lemongrass were harvested 10, 17, and 19 times, respectively, when cut at 2 feet, $2\frac{1}{2}$ feet, and maximum height (about $3\frac{1}{2}$ feet) over a 3-year period. The Java variety consistently outyielded the West Indian variety in terms of fresh grass produced, but the yield of oil per acre was greater in the West Indian variety cut at maximum and low heights because the percentage of oil was higher. The Java variety cut at medium height yielded more oil than the West Indian variety cut at the same time, because the percentage of oil was about the same and the Java variety yielded more grass. The yield of oil per acre of West Indian lemongrass was not appreciably increased by frequent cuttings. The average annual yield of oil from plots cut 10, 17, and 19 times over a 3-year period was 131.0, 132.3, and 110.5 pounds, respectively. Therefore, the maximum height appears to be the most economical height at which this variety should be harvested.

The Java variety of lemongrass yielded the most oil per acre when harvested at a height of $2\frac{1}{2}$ feet. The average annual yield of oil per acre in this treatment (217.4 pounds) was at least 100 pounds more than when the grass was cut at maximum or low height. The cost of production per unit of oil would determine whether it is more economical to harvest this variety 17 times at $2\frac{1}{2}$ feet or 10 times at maximum height over a 3-year period.

The percentage of oil was consistently higher in the West Indian variety but there was no marked or consistent differences in citral content between the two varieties or among the three harvest treatments.

The Guatemala and Java varieties of citronella grass were harvested 8, 11, and 15 times, respectively, when cut at $3\frac{1}{2}$, $4\frac{1}{2}$, and maximum height (about 6 feet) over a 4-year period.

The Java variety of citronella grass consistently outyielded the Guatemala variety in all harvest treatments. The percentage of oil in the Guatemala variety was consistently higher in all treatments and the average yield of oil per acre was somewhat higher for this variety than for the Java when harvested at maximum or low heights. At the medium height, the percentage oil in the Guatemala variety was not much greater than in the Java, and consequently the yield of oil from the latter variety was considerably higher because of the higher yield of grass.

The Guatemala variety yielded the most oil per acre when it was harvested 11 times over a 4-year period at a height of $4\frac{1}{2}$ feet. This treatment yielded 154.4 pounds of oil per acre compared to 141.6 and 136.0 pounds, respectively, for plots harvested 15 and 8 times during the same period.

The highest annual yield of oil per acre was obtained when the Java variety was cut at medium height. This treatment yielded 170.7 pounds of oil per acre per year compared to 138.6 and 119.6 pounds, respectively, from plots cut at low and maximum heights. The substantial increase in oil production obtained when the grass was cut

at 4½ feet should easily justify the cost of three extra cuttings over a 4-year period.¹³

FERTILIZING BAY TREES. A. J. Loustalot

Fertilizer treatments were applied to bay trees and 16 months later records of yield of leaves, oil, and phenol were obtained. The data showed that ammonium sulfate, alone or in combination with potassium or phosphorus, significantly increased the yield of fresh vegetative growth. Muriate of potash or superphosphate, alone or combined, did not increase the yields of vegetative material significantly, nor did potassium and phosphorus when applied with ammonium sulfate. There was no statistically significant difference in the percentages of oil or phenol among any of the treatments. Fertilizing bay trees with ammonium sulfate, as in this experiment, was uneconomical at present prices. The value of the additional oil obtained from trees treated with ammonium sulfate amounted to about half the cost of the fertilizer.¹⁴

BAMBOO

DISTRIBUTIONS. R. Ferrer Delgado

The Insular Forest Service has continued to cooperate with the station in the planting of newly introduced bamboos, in connection with the watershed-protection program. During the year 1,666 clump divisions of *Bambusa tulda* Roxb., 500 *B. longispiculata* Gamble ex Brandis, 636 *B. tuloides* Munro, 300 *B. textilis* McClure, 275 *Gigantochloa apus* (Roem. & Schult.) Kurz ex Munro, 225 *Sinocalamus oldhami* (Munro) McClure, and 200 *Dendrocalamus strictus* (Roxb.) Nees were supplied to the Forest Service. In cooperation with the Soil Conservation Service, the station has supplied 1,832 clump divisions of *B. tulda* and other species to private individuals.

ROOTING SIDE-BRANCH CUTTINGS. R. Ferrer Delgado

An experiment was initiated in an attempt to root bamboo by side-branch cuttings, using several rooting media and two plant growth regulators, alphanaphthylacetamide and indolebutyric acid, and two degrees of light. Riverbank soil and sand proved to be the most satisfactory rooting media. Other media such as vermiculite and peat plus sand were as good, but riverbank soil has the advantage of being cheaper and more easily obtainable. The hormone treatments had no significant effect on rooting. Cuttings planted under shade rooted better than those planted under direct sunlight.

CROPS FOLLOWING BAMBOO. R. Ferrer Delgado

Four crops, representing the grasses, legumes, roots, and fruits, were tested on land on which bamboo had previously grown. The results obtained to date and the general appearance of all crops planted indicated that successful cropping practices may be followed immediately in areas previously planted to bamboo.

¹³ LOUSTALOT, A. J. and FERNÁNDEZ POL. THE EFFECT OF HARVESTING CITRONELLA AND LEMONGRASS AT THREE HEIGHTS ON YIELD AND OIL CONTENT. Amer. Soc. Agr. Jour. 41. [In press.] 1949.

¹⁴ LOUSTALOT, A. J. THE EFFECT OF FERTILIZER TREATMENTS ON YIELD OF BAY LEAVES, OIL, AND PHENOL. Amer. Soc. Hort. Sci. Proc. 53: 517-519. 1949.

FERTILIZING BAMBOO. R. Ferrer Delgado

No significant difference in growth was observed in an experiment where different fertilizer treatments were applied to various bamboo species except *Bambusa tulda*. The culm growth of fertilized clumps of this species was consistently better than the checks. The other species may show response to the fertilizer as time goes on.

An experiment was started in October 1947 to observe and measure the effect of annual applications of filter-press cake, ammonium sulfate, superphosphate, and potassium chloride on *Bambusa tulda*. The data obtained to date show marked differences between treatments as compared with the checks, especially between the ammonium sulfate and the unfertilized clumps. The growth and vigor of the clumps fertilized with ammonium sulfate was almost double that of the checks.

SPACING BAMBOO. F. Montalvo Durand

In 1946 a planting of *Bambusa tulda* was made at three different spacings: 15×15 feet, 20×20 feet, and 25×25 feet on the square, on a Mucara silty clay loam at Cidra. The object of this experiment was to determine the most desirable planting distance for this species. Recent growth measurements show that the clumps planted at 25×25 feet have more and bigger culms per clump than those planted closer.

MISCELLANEOUS**WATER FOR PLANTS.** R. H. Hageman, H. E. Warmke, and E. P. Hume

The major portion of the water used in the greenhouses comes from the spring at Las Mesas, via the station storage reservoirs. This water has a total solids content of 125–150 p. p. m., and a pH of 8.8. Continuous application of this water to greenhouse plants produced iron chlorosis, apparently induced by the high pH.

Another source of water supply for the greenhouses has been the pond water that drains from La Jagua. This water has been shown to contain high concentrations of water-soluble manganese (1 p. p. m.) at certain seasonal periods. The high manganese content plus the fact that the water may be contaminated with pathogenic organisms makes it undesirable for continued use in the greenhouse.

The installation of a 750-gallon storage tank on top of the new head house and the use of other existing equipment has made it possible to neutralize the Las Mesas water. The unchlorinated waste water from the chlorinator is piped to two separate 500-gallon cement tanks located in the greenhouse. When one of these two tanks is full, 170 ml. of H_2SO_4 acid (1–10) is added and mixed and the contents pumped into the storage tank. By alternate use of the two cement tanks an adequate supply of water with a pH ranging from 6.6 to 6.8 is maintained for use in the greenhouse.

COFFEE**AGRONOMIC STUDIES.** J. Leria¹⁵

Yields of the Columnaris variety of *Coffea arabica* L., from Java, and the West Indian variety were compared for the fifteenth crop year

¹⁵ Member of the staff of the Agricultural Experiment Station of the University of Puerto Rico.

in 1948. Columnaris variety yielded 1,063 pounds per acre of marketable coffee in 1948 against 231 pounds for the Puerto Rican variety. Apparently, the irregular rain received during the year, affected the Puerto Rican variety more than the Columnaris variety. The average acre yields over a 15-year period leave the Columnaris variety well in front with 1,136 pounds as compared with 619 pounds for the West Indian variety.

WEATHER

YEARLY DATA. W. Vargas

The rainfall for the last 6 months of 1948 was 54.11 inches, or 5.17 inches above the 50-year average. For the first 6 months of 1949 the rainfall was 22.66 inches, or 7.22 inches below the 51-year average. Only July, November, December, and March had above-average precipitation. The rainfall for the remainder of the year was below average. The total rainfall for the fiscal year 1948-49 was 76.77 inches, which was 3.05 inches below the 50-year average of 79.82 inches.

The mean temperature record at Mayagüez, P. R., for the fiscal year 1948-49 was 77.5° F., which was only 0.2° higher than the 50-year average of 77.3°.

PUBLICATIONS ISSUED

The following publications were issued during the year:

- CHILDESS, N. F., SEGUINOT ROBLES, P., and LOUSTALOT, A. J. Bay oil production in Puerto Rico. Puerto Rico (Mayagüez) Fed. Expt. Sta. Cir. 30, 32 pp., illus. 1948.
- HUME, E. P. Some ornamental vines for the Tropics. Puerto Rico (Mayagüez) Fed. Expt. Sta. Cir. 31, 72 pp., illus. 1949.
- PLANK, H. K. Life history, habits, and control of the coconut rhinocerus beetle in Puerto Rico. Puerto Rico (Mayagüez) Fed. Expt. Sta. Bul. 45, 35 pp., illus. 1948.
- PLANK, H. K., and WINTERS, H. F. Insect and other pests of ciachona and their control in Puerto Rico. Puerto Rico (Mayagüez) Fed. Expt. Sta. Bul. 46, 16 pp., illus. 1949.

The following articles were published in periodicals of the Department:

- JONES, M. A., PAGÁN, C., McGOVAN, E. R., GERSDORFF, W. A., and PICQUETT, P. G. A further toxicological comparison of *Derris* and *Lonchocarpus*. Jour. Agr. Res. 78 (7): 191-196. 1949.
- JONES, M. A., and VICENTE, G. C. Criteria for testing vanilla in relation to killing and curing methods. Jour. Agr. Res. 78 (11): 425-434. 1949.
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- PAGÁN, C., and LOUSTALOT, A. J. Comparison of chemical values with the toxicological rotenone equivalent of *Derris* and *Lonchocarpus* roots. Jour. Agr. Res. 78 (7): 197-205, illus. 1949.

WHITE, D. G., PAGÁN, C., and JONES, M. A. Production of *Derris elliptica* in relation to type of cutting and age at harvest. *Jour. Agr. Res.* 77 (1) : 18-24. 1948.

The following articles were published by the station staff in periodicals outside the Department:

- BARTLETT, K. A. Federal Experiment Station in Puerto Rico. *In Rev. Azucarera*, pp. 23-25, 59, illus. San Juan, P. R. 1948.
- BARTLETT, K. A. USDA-34, A sweet corn for the Tropics. *Sugar Jour.* 11 (9) : 27-28. 1949.
- HAGEMAN, R. H. Rapid method for extracting constituents of *Derris* roots. *Analyt. Chem.* 21: 530. 1949.
- HUME, E. P. Puerto Rico's Christmas tree. *N. Y. Bot. Gard. Jour.* 49 (588) : 284-287, illus. 1948.
- HUME, E. P. Coir dust or cocopeat—a byproduct of the coconut. *Econ. Bot.* 3 : 42-45, illus. 1949.
- HUME, E. P., and WINTERS, H. F. The "palo de tomate" or tree tomato. *Econ. Bot.* 3 : 140-142, illus. 1949.
- JONES, M. A., and PAGÁN, C. Determination of rotenone in small samples. *Assoc. Off. Agr. Chem. Jour.* 31: 684-687, illus. 1948.
- LEONARD, O. A., LOUSTALOT, A. J., and FERRER, R. Progress report on weed control experiments in Puerto Rico. *In South. Weed Conf. Proc.*, Stoneville, Miss., pp. 7-10b. June 10, 1948.
- LOUSTALOT, A. J., and CERNUDA, C. Experimentos de la curación de la vainilla en Puerto Rico. *Hacienda* 43 (12) : 50-51, illus. 1948.
- LOUSTALOT, A. J. and CERNUDA, C. Effect of tropical kudzu on yield and composition of forage grasses. *Trop. Agr. [Trinidad]* 25 (12) : 41-44. 1949.
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- LOUSTALOT, A. J., and FERRER, DELGADO, R. Summary of a discussion on weed control experiments in sugarcane. *In Rev. Azucarera*, p. 37. San Juan, P. R. 1948.
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- PAGÁN, C., and WHITE, D. G. The evaluation of rotenone in *Derris elliptica* on the basis of total chloroform extractives. *Assoc. Off. Agri. Chem. Jour.* 32: 143-146. 1949.
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- WARMKE, H. E., and CRUZADO, H. J. The flowering and seed-setting of sweet-potatoes in Puerto Rico. *Science* 109 (2821) : 62-63. 1949.
- WHITE, D. G., PAGÁN, C., and MANGUAL, J. C. The effect of mulching *Derris elliptica*. *Trop. Agr. [Trinidad]* 24: 131-136, illus. 1947.
- WINTERS, H. F. Native orchids of Puerto Rico. *Amer. Orchid Soc. Bul.* 18: 355-361, illus. 1949.





